

## China's renewable energy law and policy: A critical review

Junxia Liu

School of Law, Shandong University, Jinan 250100, China



### ARTICLE INFO

**Keywords:**

Renewable energy  
Law and policy  
Achievements and problems  
Improvement  
China

### ABSTRACT

Renewable energy, as an important part of the world's energy system, is conducive to the harmonious development of humanity and nature. China has been paying considerable attention to renewable energy given the growing pressure of energy shortages and environmental deterioration. The legal framework of renewable energy in China has greatly contributed to the achievements already made in this field; however, it is still insufficient to integrate renewable energy into the national energy system. This paper, in light of the comparisons of various state practices, critically reviews the problems of China's renewable energy law and policy such as problems with fragmentation, obsolescence, and lack of operability. In addition to identifying the consequent disadvantages, this review also presents improvement recommendations.

### 1. Introduction

The past few decades have witnessed fossil fuels and other non-renewable natural resources heading towards depletion and environmental pollution becoming increasingly serious [1]. As an alternative energy source, renewable energy has been considered the strategic choice to combat the energy crisis, reduce environmental pollution, and promote socially and economically sustainable development [2]. China is currently the largest energy consumer in the world due to its ongoing rapid industrialization and urbanization [3]. However, the remaining exploitation durations of coal, oil and natural gas resources in China are less than 100, 15 and 30 years respectively. The reserves of the main traditional natural resources are all below the world average level [4]. As a result, the Chinese government has decided to take various measures to vigorously develop renewable energy [5].

China's renewable energy law and policy system, as an essential supportive factor, has played a vital role in speeding up the exploitation of renewable energies. The statistics of the National Energy Administration (NEA) show that China's renewable energy has increased spectacularly since the 12th Five Year Plan. Wind and solar power installed capacities have especially maintained rapid annual growth, with both ranking first in the world for years [6]. Nonetheless, there are limitations within the current framework of China's renewable energy law and policy that impede the further development of renewable energy. Therefore, improving China's legal and policy system of

renewable energy according to the present situation of renewable energy industry is of great theoretical and practical significance.

This paper has three main objectives. First, to sort out the framework of China's renewable energy law and policy; second, to identify the advantages as well as disadvantages of the current legal framework by a comparative review of other state practices; third, to present suggestions to establish a more systematic and efficient renewable energy law and policy system.

### 2. Framework of China's renewable energy law and policy

Before the 1990s, the main purpose of the development and utilization of renewable energy in China was to supplement the shortage of agricultural fuels. The relevant guidelines at that time were thus basically rural energy construction policies. From the 1990s to 2005, specialized policies and laws for renewable energy were gradually released that approached the issue of air pollution in addition to rural energy. Among them, the most important one is the Renewable Energy Law (REL), which came into being in 2005 and was amended in 2009. There are also related laws regarding the issue of renewable energy, such as the general energy laws or environmental and climate protection laws. China has developed a series of five-year, medium and long-term plans that set out guidelines and objectives for the promotion of renewable energy. These national plans enjoy special positions in the system of renewable energy law and policy and sometimes even produce more

**Abbreviations:** RE, Renewable Energy; NDRC, National Development and Reform Commission; MOF, Ministry of Finance; MOC, Ministry of Construction; SERC, State Electricity Regulatory Commission; MHUD, Ministry of Housing and Urban-Rural Development; MLR, Ministry of Land and Resources; MST, Ministry of Science and Technology; PC, People's Congress; AR, Autonomous Region; SCNPC, Standing Committee of National People's Congress; SC, State Council; MOA, Ministry of Agriculture; NPC, National Planning Commission; NSC, National Science Commission; NETC, National Economic and Trade Commission

*E-mail address:* [liujunxia@sdu.edu.cn](mailto:liujunxia@sdu.edu.cn).

<https://doi.org/10.1016/j.rser.2018.10.007>

Received 1 May 2018; Received in revised form 24 August 2018; Accepted 4 October 2018

Available online 23 October 2018

1364-0321/ © 2018 Elsevier Ltd. All rights reserved.

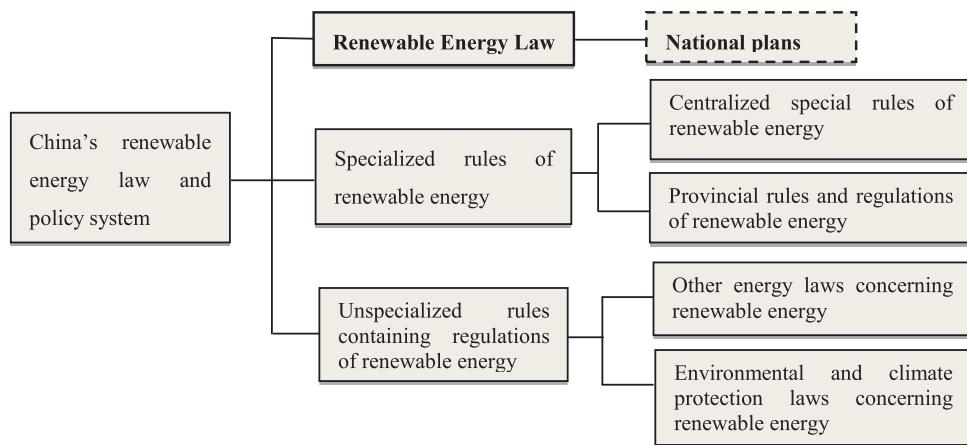


Fig. 1. General framework of China's renewable energy law and policy.

efficient effects of implementation than the laws. Thus far, China has formed a comprehensive renewable energy legal system essentially based on the REL and supplemented by other related laws and policies (Fig. 1).

### 2.1. Specialized rules of renewable energy

The REL is the basic law for the exploitation and utilization of renewable energy in China. It comprehensively covers various aspects of renewable energy in its different chapters such as resources investigation and development planning, industrial guidance and technical support, popularization and application, price control and cost apportionment, economic incentives and supervisory measures, and legal responsibilities [7]. To implement the REL, the central ministries and local governments have formulated a series of department rules, local government rules and other regulatory documents.

There are special rules of renewable energy issued by different authorities at the central level. However, the implementation of renewable energy laws is not solely dependent on the “command and control” pattern, in which orders from Beijing are received by the provincial governments and then passed to municipal or county level bureaucrats [8]. Provinces (autonomous regions, municipalities) also make local legislation for the exploitation and utilization of renewable energy based on their own energy situation and economic level (Fig. 2).

### 2.2. Unspecialized rules containing regulations of renewable energy

In addition to special renewable energy laws, other laws may also involve this issue (Fig. 3). For example, as a type of energy, renewable energy is covered in the Energy Conservation Law (ECL), which encourages, *inter alia*, the development and utilization of renewable energy. The Electric Power Law also supports electricity generation through clean energy resources.

Moreover, environmental and climate protection laws also include renewable energy issues. Due to its clean and low-carbon features, renewable energy can largely reduce pollutant emissions and produce significant environmental benefits [9]. China is the world's largest emitter of greenhouse gases, sulfur dioxide, nitrogen oxides and air particulate matter because 67% of primary energy consumption and 73% of electricity generation are from coal [10]. With the increasing concern for environmental protection, the goals of improving energy efficiency and exploring renewable energy are clearly reflected in China's environmental and climate protection laws.

### 2.3. National plans

Last but not least, policy is playing a vital role in the promotion of

renewable energy. The development of renewable energy is not only a legal issue but is also a political and economic one. Therefore, China has formulated a series of national plans as important strategies for the development and utilization of renewable energy (Fig. 4). It is generally acknowledged that policies can be flexible and quick in addressing problems. Sometimes they may deliver faster and more convenient effects than the laws. The national plans thus have a high position in China's renewable energy law and policy system in terms of setting basic guidelines and periodical targets, which greatly assist in improving the market mechanism, optimizing the allocation of social resources and mobilizing the enthusiasm of renewable energy investment [11].

In summary, it can be seen that China's renewable energy legal system has made great progress from scratch after several decades of development. China has gradually formed a relatively complete law and policy system of renewable energy, mainly based on the REL and supplemented by corresponding supporting laws and regulations. Under the guidance of renewable energy policies and laws, the development and utilization of renewable energy in China has shown an unprecedent development trend.

## 3. China's achievements in renewable energy

Thanks to the REL-centered renewable energy laws and policies, China's renewable energy has entered a rapid and large-scale stage of development. Installed capacities and industrial technologies have made remarkable achievements.

### 3.1. Installed capacity of national renewable energy power

In the past decade (2008–2017), the capacity of solar, wind and hydro power installations increased at average annual rates of 135.3%, 34.6% and 7.1%, respectively. Until the end of 2017, China's installed generation capacity of renewable energy was 635 million kW, which constituted 35.7% of the total installed capacity of electric power. Among them, the 341 million kW of installed hydropower capacity holds the largest fraction, taking up as much as 19.2%; the wind power installed capacity of 164 million kW is 9.2% of the total; and the installed capacity of solar power is 130 million kW, which accounts for 7.3% [12]. The entire national consumption of renewable electricity in 2016 was 1506 billion kW, 25.3% of the total electricity consumption, with year-on-year growth of 0.9% [13].

### 3.2. Development of renewable energy technology

The application technologies of renewable energy have gradually matured, especially wind and solar energy. In recent years, low-wind

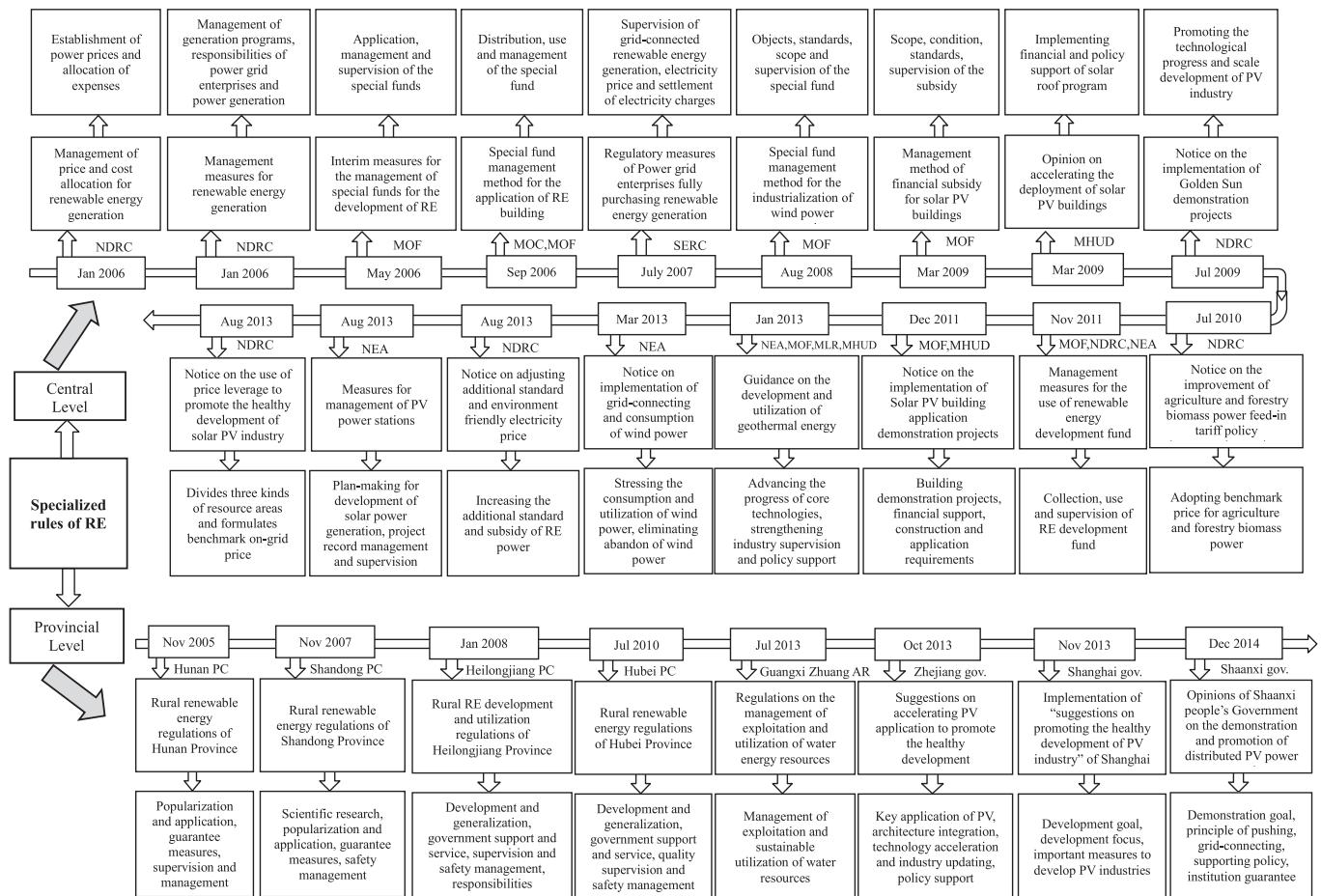


Fig. 2. Specialized renewable energy rules.

power generation technology, wind power consumption technology, and micro grid technology have made great progress. Energy storage technology is also gradually developing and improving. It has been reported that China has become a major producer and exporter of renewable energy technology. Approximately two-thirds of the world's solar panels and nearly half of the world's wind turbines are provided by China [14]. In terms of hydropower, China has built the highest double-arch concrete dam, over 300 m tall. However, there is still a large gap between China and other countries regarding the core technologies and innovation capabilities. This will be a prominent obstruction to the rapid development of China's renewable energy industries.

#### 4. Renewable energy laws and policies of other States

The smooth development of renewable energy is inseparable from the support and guarantee of laws and policies, as is clearly illustrated by several advanced countries.

##### 4.1. Germany

Germany is currently the most successful country in the promotion of renewable energy towards a sustainable energy system transition. The history of the development of renewable energy in Germany shows that timely adjustment of relevant policy and legislation is the vital factor. Early in 1991, Germany promulgated the Electric Power Transmission Act — the legislative beginning of promoting the development of renewable energy. The Act provided preferential loans and high standard subsidies for electricity suppliers. In 1998, liberalization reform was launched in the power market, which demanded further

legal incentives. As a result, the German government passed the special legislation of the Renewable Energy Law (EEG) in 2000, which has proven to be the fundamental legal basis for the strong advancement of renewable energy in Germany.

The EEG has gone through several revisions since its enactment according to the actual situation of renewable energy development and markets in Germany. EEG 2000 clearly defined the applicable object of preferential policies and obligation undertakers. It also established incentive policies for renewable energy, such as feed-in-tariffs and special subsidies, which were later improved by EEG 2004. EEG 2009 expanded from the previous 12 clauses to 66 clauses and put forward marketization terms for the first time. EEG 2012 after two partial revisions, adjusted the feed-in-tariffs reduction mechanism based on new power capacities and further encouraged renewable energy to enter the market. In EEG 2014, subsidies for renewable energy generation were strictly controlled and photovoltaic power would be promoted to the market in stages. The newest version, EEG 2017, imposed restrictions on the scale of annual bidding to avoid overexploitation of wind energy resources. Additionally, it fully introduced the renewable energy generation bidding system, which marks the comprehensive promotion of renewable energy generation marketization [15].

Because of the complete and concrete laws and policies, the renewable energies of Germany, in particular the electricity sector, have experienced unprecedented growth rates [16]. The German Renewable Energy Federation (BEE) has published scenarios showing that 47% of Germany's electricity needs could be covered by renewable sources by 2020. The BEE emphasizes that this target could be achieved as long as the policy framework is stable and reliable [17], hence the importance of policy support.

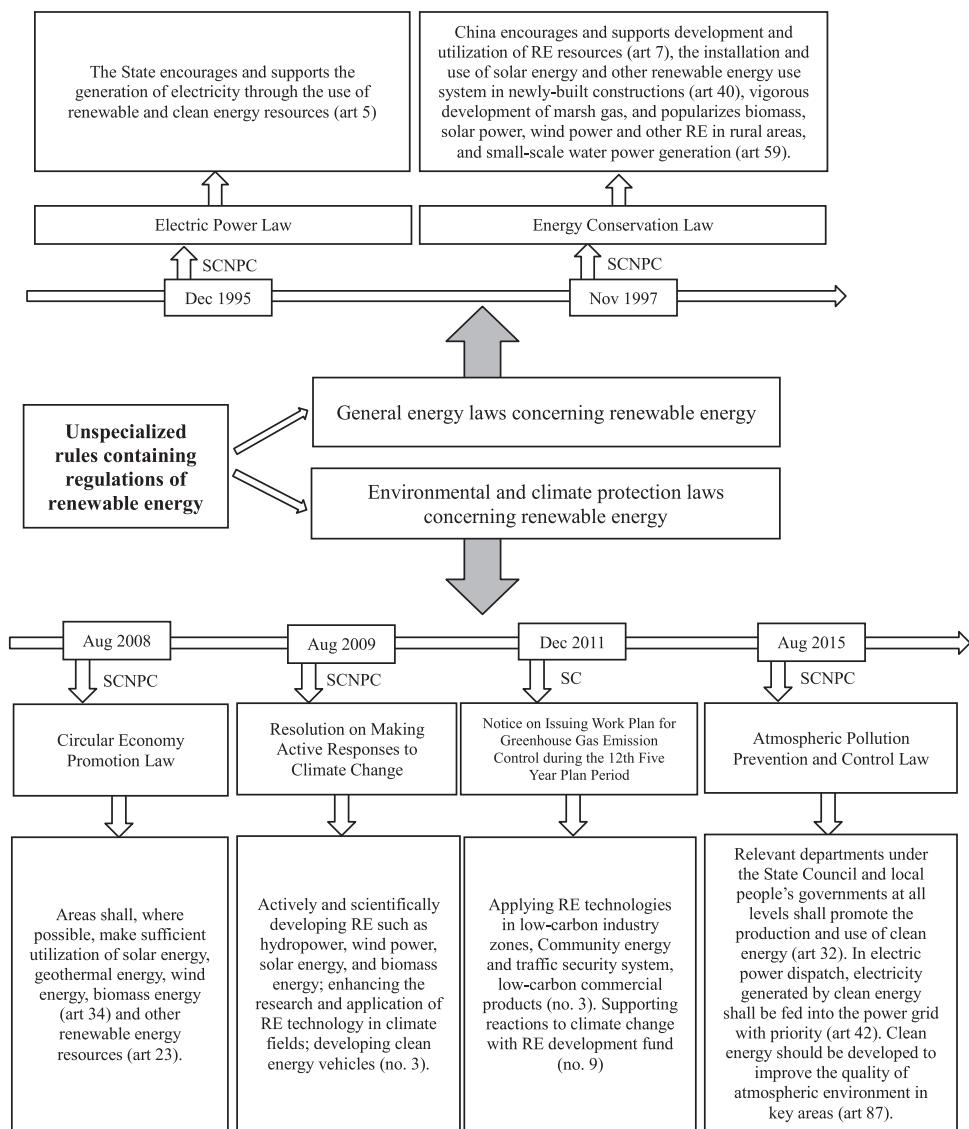


Fig. 3. Unspecialized rules containing regulations of renewable energy.

#### 4.2. Japan

Japan ranks among the world's largest powers in the field of renewable energy development and utilization, the most important reason for which is its timely revision and formulation of laws and policies on renewable energy. The Japanese government follows the principle of "legislation goes first" to ensure that the industry of renewable energy always has laws to rely upon, especially those that fit changing situations. Since 2003, a Renewable Portfolio Standard has been in practice with an annual target for electric retailers to use 1.6% of the electricity generated from renewable energy (excluding large hydropower) [18]. To further develop renewable energy industries, the Japanese government formulated a Strategic Energy Plan in 2006, which was updated in 2014 due to the Fukushima nuclear catastrophe. In 2015, the new Governmental Energy Outlook to 2030 was approved, which suggested that the appropriate share for renewable energies should reach 22–24% in 2030 [19]. Moreover, a concept of "benchmark utilization" was proposed that requires electric power enterprises to complete a certain amount of renewable energy exploitation and utilization obligations each year. Otherwise, regular improvements will be mandated, or the enterprises may even be punished by a high penalty of 1 million yen [20].

#### 4.3. Australia

Being fully aware of the significance of renewable energy to its society and economy, Australia also established a complete legal and policy system to serve as an external driving force for the development of renewable energy. In 2001, Australia promulgated the mandatory Renewable Energy Target (RET), the first country in the world to set renewable energy development goals in the form of law. The RET was extended in 2009 to ensure that 45,000 GW of electricity is derived from renewable energy sources every year by 2020, covering 20% of the country's entire electricity consumption [21]. To achieve this new aim, two Acts—the Renewable Energy (Electricity) Act and the Renewable Energy (Electricity Charge) Act—were formulated. Based on the RET, comprehensive energy laws and special laws were also enacted.

It is worth mentioning that Australia broadly applied incentive policies such as financial subsidies, tax relief and credit loans in various fields that use renewable energy, which turned out to be very effective especially in the transportation industry where much energy is needed. Maximum subsidies of 20 thousand Australian dollars were provided for the infrastructure of operating facilities that supply E10 ethanol-blended fuel and the federal consumption tax was reduced by 0.38 Australian dollars for each liter of ethanol [22].

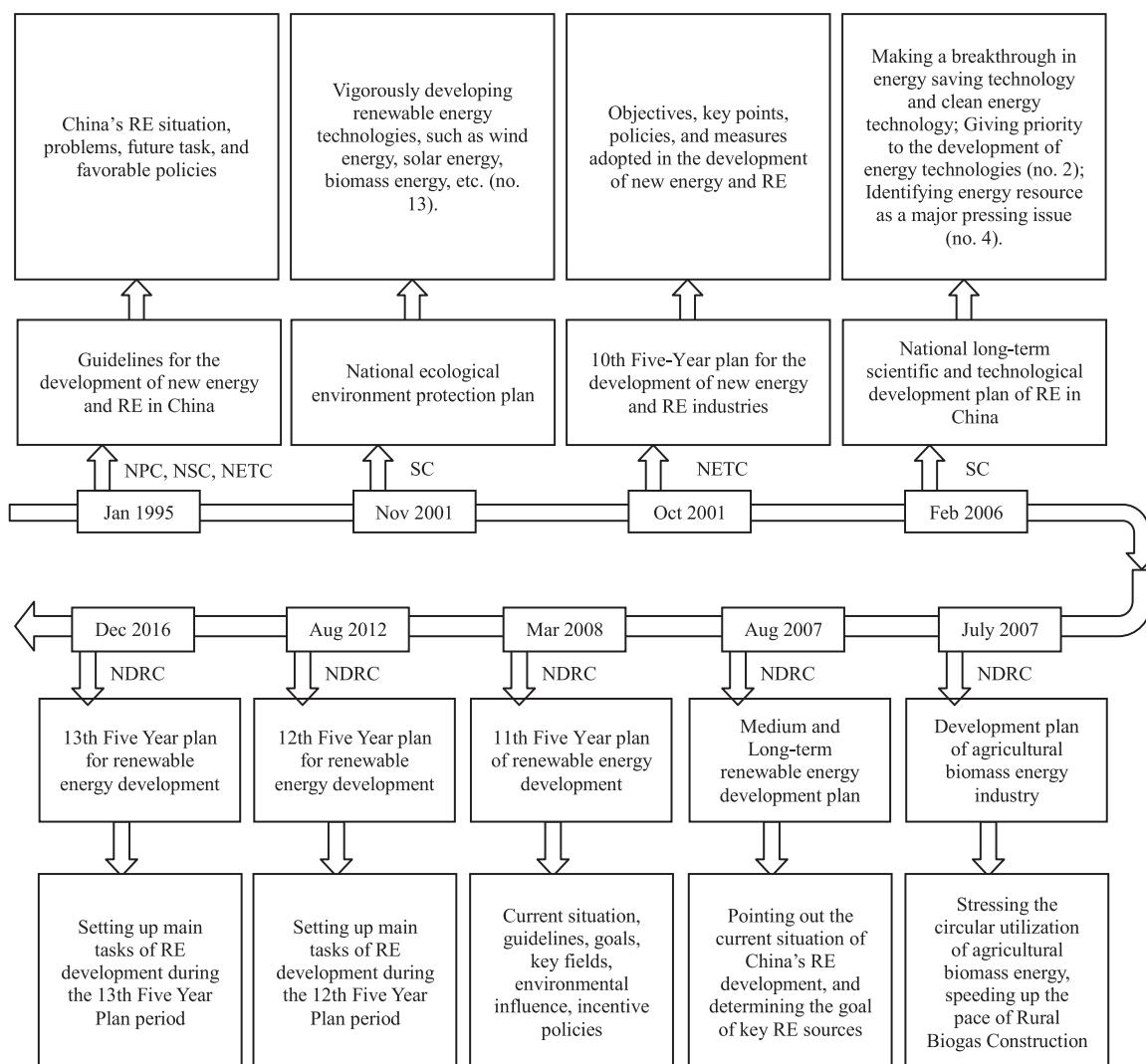


Fig. 4. National plans concerning renewable energy.

In addition, Australia launched an energy market reform that aimed to break market monopolies in the energy sector and ensure stable and affordable energy for the public. For this purpose, Australia developed a special energy market law. Measures such as attracting investment in the energy market, increasing competition and offering tax incentives were taken for the implementation. As is stipulated by the 2006 National Energy Effectiveness Framework, the self-regulatory mechanism of the market is the key to fulfilling Australia's strategic objectives of renewable energy development.

#### 4.4. France

France is in the leading position in the European Union regarding renewable energy development and utilization. The 2005 Energy Law established the guidelines for energy policy and required that the proportion of renewable energy in the energy consumption structure reach 10% in 2010. Moreover, it delineated a wind energy development zone, where the pricing mechanism was set by the government [23]. In the 2008 Renewable Energy Development Plan, it was regulated that solar panels of less than  $30 \text{ m}^2$  were free of duty. The 2010 Grenelle II Act revised the previous provisions of wind energy development and encouraged large-scale wind energy use in suitable areas. The 2014 Energy Transition for Green Growth Bill set a target to increase the fraction of renewables in final energy consumption to 32% by 2030 [24].

Based on the experience of the above countries, the advancement of

renewable energy development and utilization is to a large extent due to scientific and appropriate renewable energy laws and policies. The effective measures, which China can use for reference, can be summarized as follows: timely formulation and adjustment of laws, complete and concrete law provisions, a high standard of renewable energy utilization proportion, promotion of market competition, proper financial subsidies, and avoidance of overexploitation of renewable energy (Table 1). The advanced practices of other countries clearly reflect the shortcomings in China's renewable energy law and policy system.

Table 1  
Efficient measures taken by typical countries.

Measures	Germany	Japan	Australia	France
Timely formulation and adjustment of laws	✓	✓	✓	✓
Complete and concrete law provisions	✓	✓	✓	✓
High renewable energy utilization proportion	✓	✓	✓	✓
Promotion of market competition	✓			
Financial subsidies	✓		✓	✓
Avoidance of overexploitation of renewable energy	✓			✓

## 5. Problems arising from China's renewable energy law and policy

China's renewable energy laws and policies have provided strong driving forces to start renewable energy projects. However, compared with other countries, they are still insufficient to integrate renewable energy into the existing national energy system and scale up the development of renewable energy.

### 5.1. Complex law and policy system

The four figures in Section Two vividly exhibit the complexity of China's renewable energy law and policy system. This leads to several difficulties. First, there are large numbers of policies and laws that regulate renewable energy, including central level and local level laws, general laws and specialized laws. In this case, the regulations of a certain issue are scattered in various rules. For example, all renewable energies are generally under the uniform management of the NEA, whereas water, ocean, and geothermal energies are respectively in the charge of the Ministry of Water Resources, the State Oceanic Administration and the Ministry of Land and Resources. This institutional separation could lead to the situation that renewable energy programs have to pass multiple examinations and approvals of different departments, which is a great burden. What is more, the rules formulated by various departments could be inconsistent with one another. For example, the Notice of the National Development and Reform Commission on Issuing Administrative Provisions on Renewable Energy Power Generation stipulates that power generation enterprises can apply to be connected to the power grid as long as they have administrative licenses. However, the Electric Power Law additionally requires the power generation stations to have legal personality.

Second, the confusion between law and policy aggravates the complexity. At present, China lacks special administrative rules and local regulations regarding the development and utilization of renewable energy, except for the REL. Moreover, many of the provisions in the REL are only principles without strong practicability. Specific operations thus often rely on policy documents. Although policies are advantageous to permit flexible and faster promotion of renewable energy, in the long run, modifications of policies may not maintain stability with respect to the rights and obligations of renewable energy producers and may even weaken the authority of the law [25].

### 5.2. Vague legislation and low operability

In addition to the defects of the legal system *per se*, some provisions of laws in China are rather vague and lack operability. In contrast, one common characteristic of the legislations of Germany, Japan, Australia and France is that they are highly operational. Taking the German EEG as an example, after a principled explanation to a general provision, it will usually further explain how to apply it in specific operations or special circumstances. For example, when regulating the duty of grid connection, the EEG stipulates that the power grid operators are generally obliged to connect renewable energy generation facilities into the power grid access points without delay. In addition, at the specific level of operation it also thoroughly clarifies what procedures should be taken by the power grid operators, in what period of time the grid-connection requests should be dealt with, and what kind of responsibility the power grid operators should bear if they fail the obligations. Japan also stipulates an exact number of penalty for electric power enterprises failing the "benchmark utilization" [20].

Unfortunately, this is not the case in most of China's stipulations. Overall, the provisions related to renewable energy are too principled and generalized, probably because China started late in this area. For example, Article 13 of the REL stipulates that "the State shall encourage and support grid synchronization of power generated by using renewable energies", but there are no specific measures to implement this provision. Article 6 of the ECL regulates that "the State implements the

energy conservation target responsibility system and the energy conservation examination system and takes the completion of energy conservation targets as an item to assess and evaluate the performance of the local government and the persons in charge thereof." This article is impractical because it does not provide what the "energy conservation target" is, who should evaluate whether the target is achieved and in what process, and what kind of responsibility the local government and the persons in charge should take. Neither this law nor other supplementary rules provide detailed explanations.

### 5.3. Industry monopoly and market monopoly

At present, the biggest obstacle to the reform of China's energy industries is monopolies: industry monopolies and regional market monopolies.

Conventional energies have evolved for many years and have occupied monopoly positions in the market. Traditional energy-related industries are the major tax-payers in local places and may even be invited by local governments to invest under preferential policies. In this case, renewable energy has difficulty breaking through. For example, the rich renewable energy resources in the northeast, north and northwest of China, which cannot be consumed locally, are supposed to be transmitted to the east and south of China, where the demand for electricity is large, through extra-high voltage transmission lines. However, to protect their own power plants and related industries, governments in the east and south of China are reluctant to accept the transmitted electricity. Due to local protectionism, the installed capacity of thermal power plants has increased in 2016, the largest growth period since the 12th Five Year Plan. This is obviously not in line with the present trend and compresses the power generation space for new energies.

Some areas of renewable energy are also under the monopoly of the state. Nonetheless, this is mainly because the exploitation of renewable energy is highly risky, and the massive investment could hardly be afforded by private enterprises. Hopefully, this is only a tactic at present since the development of renewable energy is not yet mature. In the long run, market principles should play the leading role so that the public could have access to stable and affordable renewable energy resources.

### 5.4. Lack of financial subsidies

The development of renewable energy has been impeded by inadequate subsidies. The cost to develop and use renewable energy is much higher than that of conventional energy. However, financial support for renewable energy is rather limited, whereas that for fossil fuels is overexploited [26]. The additional fund for renewable energy was supposed to reach 80 billion Yuan in 2016, basically consistent with the amount of subsidy. Nonetheless, the actual collection was far below that amount, which constitutes an important reason why subsidies cannot be available in time. It has been pointed out that the power plants of most companies refuse to pay additional taxes for renewable energy, to which the REL provides no specific penalties as in Japan. Until the end of 2017, the subsidy gap for renewable energy had grown to 100 billion Yuan and would possibly break through 200 billion Yuan in 2020 [27,28].

### 5.5. Abandonment of renewable power

The phenomena of abandoning wind and solar power in some regions is becoming serious [29]. The energy sector in China was originally set up for conventional fossil fuels to be operated and managed on a large power and grid system. This discriminates against renewable energy because of its fluctuation and intermittency in production. Due to the incapacity of the power grid transmission system, there exists inconsistency between electricity generation and the power grid. As a

consequence, part of the renewable energy power could neither be exported nor consumed locally [30]. Since 2015, the abandonment problem has become severe. A considerable quantity of renewable electricity is discarded every year. Taking wind electricity as an example, average rates of 15%, 21% and 12% of wind power were discarded in 2015, 2016 and 2017, respectively [31,32]. The situations in Gansu, Xinjiang, Jilin and Inner Mongolia are even worse, where 33%, 29%, 21% and 15% were abandoned in 2017 respectively [32]. Associated with the problem of the abandonment of renewable power is “face projects”, which is usually a manifestation of political achievements. In many places these projects were quickly constructed and then quickly demolished, which is, in essence, a large waste of energy [33].

## 6. Improvement of renewable energy law and policy in China

It is inevitable that laws always lag behind. The smooth development and exploitation of renewable energy in China call for more systematic and efficient laws and policies.

### 6.1. Integration of the renewable energy legal system

Compared with other countries, China should make great efforts to improve its renewable energy legal system. The REL, which at present is the only law specifically regulating the issues of renewable energy, does not sufficiently meet practical needs. A basic law in the field of energy, the Energy Law, should be formulated as soon as possible. Based on this law, the provisions on renewable energy scattered in different laws, administrative rules, departmental regulations and local government regulations can be systematically integrated or cleaned up. The continuity and consistency of related laws and policies could also be maintained. Policies that have been proven mature by practice can be gradually raised to the level of laws or regulations to enhance their authority and binding force.

Before the formulation of the Energy Law, the existing REL should be timely tracked and assessed. In fact, renewable energy in China is now at a stage of rapid development, and is facing changing technology progress and various problems encountered in large scale advancement. Therefore, it is necessary to timely track the implementation of renewable energy laws and make requisite revisions accordingly. In this respect, the German EEG sets a good example, having been revised at least 5 times since its enactment in 2000. Regular follow-up and evaluation mechanisms will enable the government, legislators and the public to monitor the implementation and problems of the renewable energy laws and policies, and carry out standardized management of renewable energy legislation.

### 6.2. Practicability of renewable energy laws

High requirements for the practicability of laws will be helpful for interested parties to fulfill their obligations in accordance with provisions specific enough to follow. Therefore, a more specific and enforced version of the REL is needed, based on which China's State Council and relevant departments should formulate specific implementation rules [10]. Provinces, autonomous regions and municipalities directly under the jurisdiction of the central government should enact local laws and government regulations in light of the status of renewable energy in their own regions, establish renewable energy registration databases, and improve the supervision and management systems. As in advanced countries, China should also set mandatory development goals for the use of renewable energy in the form of laws and supervise their completion [34]. With respect to legal responsibilities, they should be clearly stipulated for power grid operators, oil sales enterprises, and enterprises that operate gas pipeline and heat pipe networks. Those failing to implement energy-saving measures should be strictly punished with an increased penalty [33]. Improving the preciseness and meticulousness of the REL will increase the workload of legislators but

will reduce the deviation and loopholes in the implementation of the law regarding the lack of practicability.

### 6.3. Application of market economic means

The successful experience of Germany and Australia displays that market mechanisms play a decisive role in the development and utilization of new energy. Legislators of both states focus on the application of economic means to solve legal problems. To eliminate monopoly in the energy market, China should differentiate the functions of the government and the market and strengthen the basic role of the latter. Market-driven mechanisms are essential for renewable energy development, the core of which is to establish an open and competitive modern market system so that the allocation of resources could be optimized [10]. Additionally, supportive mechanisms are needed to trigger renewable energy deployment in all sectors and provide incentives to improve the competitiveness of renewables [17]. Moreover, China should incorporate the external cost of energy into prices, balance the prices between renewable energy and traditional fossil energy, and provide equal market opportunities for renewable energy technologies. An open, free, and competitive market mechanism is the determinant of China's renewable energy development and utilization.

### 6.4. Sufficient financial support

The rapid development of renewable energy is inseparable from adequate funding, as is particularly illustrated by Japan and Germany. Renewable energy, such as wind, solar and biomass energy, has relatively high cost due to its vast capital needs, high technical requirements, long cycles and delaying benefits, and thus cannot compete with traditional energy in early stages. As a result, the cultivation of the renewable energy market needs various financial supports such as government subsidies, tax relief, mandatory market quotas, guaranteed purchases and other supportive measures. The subsidy shortage for renewable energy in China is becoming worse. To fill the gap, an effective method would be to establish a national renewable energy development fund. In the meantime, local governments at all levels are encouraged to raise funds through various channels. Provincial and municipal energy departments and agencies should, in conjunction with relevant departments, monitor and evaluate the settlement of electricity charges, the availability of subsidy funds and the operation status of enterprises [35]. Such information should be regularly issued to the public to remind enterprises of the investment and operation risks and to rationally control the development pace of renewable energy.

It needs to be noted that financial supports must be based on the national conditions and the market environment. Inappropriate subsidies might lead to excessive market distortion. The purpose of subsidies is not just to assist renewable energy industries to survive and make profits; the ultimate aim is to improve their market competitiveness to eventually get rid of subsidies.

### 6.5. Rational planning of renewable power generation

Renewable energy, especially wind and solar energy, are intermittent, unstable and hard to be adjusted for peak periods of power consumption, which reflects the new conflict of unbalanced power supply and demand. To reduce the abandonment of wind and solar power, the following aspects can be taken into consideration: First, under the existing energy system, thermal power has the *de facto* priority because of the government's annual planning of power generation indicators. In the future, the economic and social development planning should give priority to the development of renewable energy. Different levels of government should define the binding indicators of renewable energy development, such as regulation of the minimum guaranteed purchase hours for renewable energy generation and sign preferable contracts with power grid operators to ensure that new

energy power is used first [34]. Second, with the intermittent characteristics of wind and solar power, power storage and heat storage devices should be added on the supply side. On the demand side, smart power meters could effectively guide power consumption and realize the efficient production and rational utilization of renewable energy generation. Third, similar to Germany, China could also restrict the development scale of wind and solar energy power to avoid the over-exploitation of wind energy resources [36]. “Face projects” should be strictly forbidden to prevent the waste of funds and resources.

## 7. Conclusions

Energy demand in China has risen rapidly and reached an unprecedented level due to the country's high-speed economic growth and modern development. The shortage of energy and the deterioration of the natural environment have seriously restricted the sustainable development of China's economy and society. To some extent, renewable energy is a solution that strikes a balance among energy security, environmental protection and economic efficiency. It is undeniable that China's renewable energy is in a rapid developmental stage. However, compared with the potential, it is still underexploited. There is still much room to develop large-scale renewable sources in the future energy system, along with technological and economic development.

The current pressure from the energy supply requires a growing proportion of renewable energy in total primary energy consumption. These real demands urgently need to be answered by the REL and other related laws and policies. China's present legal framework for renewable energy is of limited help due to its fragmentation, obsolescence, and low operability. The Chinese government needs to integrate the renewable energy law and policy system, improve the practicability of the REL, apply market economic means, provide sufficient financial support, and rationally plan renewable power generation. It is hoped that through these means more systematic and efficient supports could be provided for the overall healthy development of the renewable energy industry.

## Acknowledgments

This research is supported by the 2016 Scientific and Technological Projects of State Grid Corporation of China (SGSDDK00KJJS1600067); the Shandong University Humanity and Social Science Major Project (17RWZD19); and the Shandong Social Science Planning Project (18DFXJ03).

## References

- [1] Dong J, Xue G, Dong M, Xu X. Energy-saving power generation dispatching in China: regulations, pilot projects and policy recommendations—a review. *Renew Sustain Energy Rev* 2015;43:1285–300.
- [2] He Y, Xu Y, Pang Y, Tian H, Wu R. A regulatory policy to promote renewable energy consumption in China: review and future evolutionary path. *Renew Energy* 2016;89:695–705.
- [3] Bai X, Shi P, Liu Y. Society: realizing China's urban dream. *Nature* 2014;509(7499):158–60.
- [4] Zhao Z, Zhang S, Hubbard B, Yao X. The emergence of the solar photovoltaic power industry in China. *Renew Sustain Energy Rev* 2013;21:229–36.
- [5] Zhang D, Wang J, Lin Y, Si Y, Huang C, Yang J, Huang B, Li W. Present situation and future prospect of renewable energy in China. *Renew Sustain Energy Rev* 2017;76:865–71.
- [6] Shen W. Who drives China's renewable energy policies? Understanding the role of industrial corporations. *Environ Dev* 2017;21:87–97.
- [7] Ministry of Ecology and Environment of People's Republic of China. <[http://www.zhb.gov.cn/gzfw\\_13107/zcfg/fl/201605/t20160522\\_343386.shtml](http://www.zhb.gov.cn/gzfw_13107/zcfg/fl/201605/t20160522_343386.shtml)>, [in Chinese].
- [8] Chung JH. Studies of central-provincial relations in the People's Republic of China: a mid-term appraisal. *China Q* 1995;142:487–508.
- [9] Silva S, Soares I, Afonso O. Economic and environmental effects under resource scarcity and substitution between renewable and non-renewable resources. *Energy Policy* 2013;54:113–24.
- [10] Yang XJ, Hu H, Tan T, Li J. China's renewable energy goals by 2050. *Environ Dev* 2016;20:83–90.
- [11] Zhang M, Zhou D, Zhou P, Chen H. Optimal design of subsidy to stimulate renewable energy investments: the case of China. *Renew Sustain Energy Rev* 2017;71:873–83.
- [12] CEC. Power statistics basic data list from 2009 to 2017. <<http://www.cec.org.cn/guizhuyutongji/tongjinxini/niandushuju/>>, [in Chinese].
- [13] NEA. Bulletin on monitoring and evaluation of renewable energy power development in 2016<<http://zfxgk.nea.gov.cn/auto87/201704/P020170418459199124150.doc>>, [in Chinese].
- [14] Clairvoyant. China has become a major producer and exporter of renewable energy technology. <[http://www.sohu.com/a/159349902\\_788378](http://www.sohu.com/a/159349902_788378)>, [in Chinese].
- [15] Voss A, Madlener R. Auction schemes, bidding strategies and the cost-optimal level of promoting renewable electricity in Germany. *Energy J* 2017;38:229–64.
- [16] Oschmann V. A success story - the German renewable energy act turns ten. *Renew Energy Law Policy Rev* 2010;1:45–59.
- [17] Hinrichs-Rahlwes R. Paving the way towards sustainable energy security: lessons learnt from Germany. *Renew Energy* 2013;49:10–4.
- [18] Chen WM, Kim H, Yamaguchi H. Renewable energy in eastern Asia: renewable energy policy review and comparative SWOT analysis for promoting renewable energy in Japan, South Korea, and Taiwan. *Energy Policy* 2014;74:319–29.
- [19] Komiya R, Fujii Y. Assessment of post-Fukushima renewable energy policy in Japan's nationwide power grid. *Energy Policy* 2017;101:594–611.
- [20] Tang X, Chen X. Research on renewable energy laws and policies in developed countries. *J Southwest Pet Univ (Soc Sci Ed)* 2016;18(5):1–7. [in Chinese].
- [21] Buckman G, Diesendorf M. Design limitations in Australian renewable electricity policies. *Energy Policy* 2010;38(7):3365–76.
- [22] Nelson T, Nelson J, Ariyaratnam J, Camroux S. An analysis of Australia's large scale renewable energy target: restoring market confidence. *Energy Policy* 2013;62:386–861.
- [23] Wang A. Energy and world economic development. Beijing: Geological Publishing House; 2008. [in Chinese].
- [24] WNA. Nuclear Power in France. Released Mar 2018. <<http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/france.aspx>>.
- [25] Chang Y, Wang N. Legal system for the development of marine renewable energy in China. *Renew Sustain Energy Rev* 2017;75:192–6.
- [26] Chen Y. Energy subsidies reform roadmap from the beginning of the abolition of fossil energy subsidies. *China Economic Herald*. <<http://www.ceh.com.cn/ztdb/jnjpkz/918297.shtml>>, [in Chinese].
- [27] Baijiaohao. The shortfall of renewable energy subsidies in China has reached 100 billion yuan until 2017. <<https://baijiaohao.baidu.com/s?id=1591168933095173708&wfr=spider&for=pc>>, [in Chinese]; 2017.
- [28] OFweek. The shortfall of renewable energy subsidies is about 50 billion – thermal power is the reason? Released Jan 16, 2017. <<http://solar.ofweek.com/2017-01/ART-260009-8420-30091926.html>>, [in Chinese].
- [29] Zhang L, Li J. Research on the law of promoting the development of renewable energy industry in China. *Hebei Law Sci* 2016;34(4):127–34. [in Chinese].
- [30] Wang J, Li L. Sustainable energy development scenario forecasting and energy saving policy analysis of China. *Renew Sustain Energy Rev* 2016;58:718–24.
- [31] NEA. Development of wind power industry in 2015. <[http://www.nea.gov.cn/2016-02/02/c\\_135066586.htm](http://www.nea.gov.cn/2016-02/02/c_135066586.htm)>, [in Chinese]; NEA. Wind power status report in 2016. <[http://www.nea.gov.cn/2017-01/26/c\\_136014615.htm](http://www.nea.gov.cn/2017-01/26/c_136014615.htm)>, [in Chinese].
- [32] NEA. Wind power grid operation in 2017. <[http://www.nea.gov.cn/2018-02/01/c\\_136942234.htm](http://www.nea.gov.cn/2018-02/01/c_136942234.htm)>, [in Chinese].
- [33] Yi Y, Qin L. The drawbacks of China's energy conservation law and renewable energy law reflected from the power shortage of South China. *J Mudanjiang Univ* 2012;21(2):91–4. [in Chinese].
- [34] Gong X. Legal construction of the priority right of renewable power—a logical analysis based on the recent abandoned renewable power phenomenon. *J China Univ Geosci (Soc Sci Ed)* 2017;17(1):29–36. [in Chinese].
- [35] Liu L, Liu C, Wang J. Deliberating on renewable and sustainable energy policies in China. *Renew Sustain Energy Rev* 2013;17:191–8.
- [36] Nedelman B, Lai Y. Interpretation of EEG 2017 on onshore wind power. *Wind Power* 2016;10:42–5. [in Chinese].